

WHAT IS SYSTEMATIC ENTOMOLOGY?¹

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Abstract.—Systematic entomology is defined and its position as the basic regimen of entomology is discussed. Systematics is indispensable as it serves the general need, biological control problems, ecological and environmental studies, veterinary entomology, etc. Examples of the difficulties and rewards for the systematic entomologist are given.

Most systematic entomologists have at least a fairly good idea of the aims and content of their branch of science, but among laymen and even scientists of physical and chemical disciplines there is some misapprehension. Some scientists believe that systematic entomology is not even a science, apparently because it does not ordinarily require a laboratory filled with expensive and complex apparatus and because, again ordinarily, controlled experiments are not performed. However, systematic entomology is indeed not only a science but the basic regimen of entomology.

Let us define our terms. The "preliminary definition" of *science* by Caws (1965:11) should suffice for our purpose, inasmuch as it is in the restricted sense we require and is even more philosophically rigorous than the dictionary definitions, while at the same time in agreement with them: "science is the explanation of nature on its own terms, together with all that follows from doing that successfully, such as the ability to predict how things will behave and hence to control them." Caws' 354-page book, entitled "The Philosophy of Science, a Systematic Account," is a commentary on this definition.

The word *research* is defined in the scientific sense in the great *Oxford Dictionary* as "a search or investigation directed to the discovery of some fact by careful consideration or study of a subject; a course of critical or scientific inquiry." The *Third New International Dictionary of the English Language* (Webster's) is more prolix: "a studious inquiry or examination; *esp* critical and exhaustive investigation or experimentation having for its aim the discovery of new facts and their correct interpretation, the revision of accepted conclusions, theories, or laws in the light of newly discovered facts, or the practical application of such new or revised conclusions, theories, or laws." It is thus evident that controlled experimentation is not a necessary part of research in its broad sense, but that hypothesis and testing in some form, even when the latter is not feasible by direct experimentation, definitely are.

The definition of *systematic* is not quite so easy. The word is an adjective on which the noun *systematics* is based. These words are in turn derived from the noun *system*, which is merely a way of referring to the fact that in

science the various parts of the study of a subject agree with each other and hang together in a cohesive whole. Science, after all, is only a systematic way of considering nature.

Systematics is also known as taxonomy. A distinction is often made between these two terms, but in general they are virtually synonymous. The dictionaries define both as "the science of classification" and cite them as synonyms of each other. The term *classification*, however, when narrowed to its meaning in biology, is too narrow and entails unfortunate connotations carried over from its use in non-biological fields.

Let us, therefore, refer to a few texts on systematics (or taxonomy) published since 1960, viz. Simpson (1961), Cain (1963), Hennig (1966), Blackwelder (1967), Mayr (1969), Michener (1970), and Ross (1974). There is much more in the literature referring to the basics of zoological science, but these works can be considered representative and authoritative enough to use in drawing conclusions.

Simpson (1961) says that "systematics is the scientific study of the kinds and diversity of organisms and all relationships among them." He also quotes Hennig's *Grundzüge der phylogenetischen Systematik* (1950), the precursor of his revised work published in English in 1966, ". . . one must first make clear that there is a systematics not only in biology, but that it constitutes an integrating component in any science whatsoever."

Cain (1963): "In recent years it has been gradually realized that taxonomy is not merely a necessary pigeon-holing but also one of the most important activities in biology, requiring a synthesis of all other biological pursuits for its proper performance"

Hennig (1966) states, ". . . systematics in the most general sense is equivalent to order, rationalization, and in a certain context explanation of the world of phenomena; and . . . in this sense systematics is a very broad task of all natural sciences, and particularly of all biological disciplines," and at another place, ". . . systematics fundamentally means any investigation of relations between natural things and natural processes insofar as they have the character of conformity to law."

Blackwelder (1967) gives a definition on the first page of his text: "Both taxonomy and classification, and all the other aspects of dealing with organisms and the data accumulated about them, are included in systematics, which is the general term that covers all aspects of the study of kinds. Therefore, systematics is the study of the kinds and diversity of organisms, their distinction, classification, and evolution." He uses as a prefatory quotation the following sentence from Simpson (1945): "taxonomy is at the same time the most elementary and the most inclusive part of zoology, most elementary because animals cannot be discussed or treated in a scientific way until some taxonomy has been achieved, and the most inclusive because taxonomy in its various guises and branches eventually

gathers together, utilizes, summarizes, and implements everything that is known about animals, whether morphological, physiological, psychological, or ecological."

Mayr (1969) follows Simpson (1961), already quoted, and distinguishes taxonomy as the "theory and practice of classifying organisms."

Ross (1974) considers that the term *taxonomy* is a synonym of systematics and that "systematics has the majority vote as the inclusive name to be applied to the total field of investigation that we are discussing." He uses the newer term "biosystematics . . . as the investigational field of systematics based on any scientific information that can be brought to bear on the problems of the evolution of species, whether they concern speciation or phylogeny." Inasmuch as systematics is not restricted to biology (see Hennig, 1950), the term *biosystematics* is nothing more than a restrictive term referring to systematics in biology, and is superfluous when used in purely biological context.

In a remarkably clear, balanced, and suggestive article on "Diverse Approaches to Systematics," Michener (1970) cites Simpson's definition of systematics. He also states, "one might think that this (Simpson's definition of systematics) includes everything in population biology . . . but the systematic approach is *less broad*" (my italics). I would consider that it is less broad only if it concerns a part of biosystematics, one dealing only with certain kinds of organisms. The systematics of all biology certainly must include population biology, at least as a source of data.

There is much agreement among these definitions. Sifting them out, one may come to the conclusions that 1) the term *systematics* is becoming accepted as the term including both taxonomy and classification, whether or not some synonymy is involved, and 2) systematics is becoming continually broader in scope, using ever more various ways of looking at organisms.

Systematics in biology is based upon two assumptions, 1) that all biological science is founded on the species concept, and 2) that all kinds of data are grist for its mill.

It is the basic concern of systematics to place the concept of an organism in proper relationship within the species concept—is it that of a species, subspecies, of a higher or lower taxonomic rank, and, establishing the rank, what relationships in time, space, and kind does it bear to those of other organisms, especially those closest to it?

The last few decades have seen the field of systematics expand enormously; some have even said that biology is changing from many more or less well-defined disciplines into one all-embracing subject. The concept of holomorphology was stressed by Hennig as early as 1950. Anything even remotely to be considered as morphological (even cell and chromosome structure), physiological characteristics (because organic chemicals are substances and have form), and proteins, all fall within the scope of mor-

phology because they have form (*morphē*). The use of the genitalia of both sexes and their associated structures has now become commonplace, even considered necessary, in the study of any kind of insect. Internal structures are becoming increasingly important. Arnold (1972a, 1972b) has recently been pursuing the study of insect haemocytes with reference to systematics.

The proceedings of an international conference on systematic biology have been published in a volume (Internatl. Conf. Syst. Biol., 1969) that includes papers on systematics of populations, ecological aspects of systematics (in plants and animals), molecular data in systematics, systematic significance of isolating mechanisms, comparative animal behavior in systematics, comparative cytology in systematics, biometric techniques in systematics, and computer techniques in systematics. Mayr, in the opening paper in the volume, closes with the statements "Finally, let us remember that in virtually every taxonomic finding certain generalizations that are of value and broad interest to biology as a whole are implicit" and "It is my sincere belief that systematics is one of the most important and indispensable, one of the most active and exciting, and one of the most rewarding branches of biological science. I know of no other subject that teaches us more about the world we live in."

Edward O. Wilson, in the final paper summarizing that conference, asks, "What is a *pure* systematist? He might be defined as a biologist who works on such a large number of species that he has only time enough to consider classification and phylogeny. If he narrows his focus, his unique knowledge provides him with a good chance to make discoveries in genetics, ecology, behavior, and physiology. But then we come to know him as a geneticist, or an ecologist, or a behaviorist, or a physiologist. It clearly will not do to define systematics as classification plus all these other fields, because that would be robbing the discipline of its true meaning. I think it would be appropriate just to acknowledge everything that systematists do for the rest of biology (and that is a great deal indeed) . . ." He also notes "It has occasionally been said that the perfect experimental biologist selects a problem first and then seeks the organism ideally suited to its solution. In contrast, the typical systematist selects the organism first—for the love of it. Now this is a great strength, for the systematist devotes his career to the organism and thereby often comes upon problems of general significance that would be discovered otherwise; . . ."

In a paper to be delivered at the BARC Symposium II, at the Beltsville Agricultural Research Center, on 8–11 May 1977, Foote (in press) has brought together an imposing list of references and much data on the importance of systematics to the general need, biological control problems, ecological and environmental studies, veterinary entomology, etc.

Mathematics and its offspring computer technology are becoming more and more used in systematics. Numerical taxonomy, which burst upon the

scene with great éclat as a new solution to the problems of systematics, is now taking its more logical position as taxonomic mathematics. Mathematics, even of the most sophisticated kind, is still the handmaiden and not the director of the sciences.

Many new ways of working with insects are coming to hand, new ways of getting at them and new ways of looking at them. Electron microscopy is allowing entomologists to see things they never saw before. But entomologists, especially those practicing systematics, are too few and have too much to do to take full advantage of these new ways and means. The best solution of a problem is often too time-consuming and costly; the systematist must therefore be content in many instances with a solution that is merely good enough at the moment. Perhaps he may be able to do something better later. At the worst, other entomologists, some perhaps better situated, will find in more detail, discover new facts, and make new hypotheses sooner or later.

Heiser (1966) has remarked that the "process of character selection, rejection, and weighting by taxonomists is one of the great mysteries to some non-taxonomists and to beginning taxonomists . . ." I would say that it is part of the taxonomist's way of experimenting, his process of hypothesizing, testing, and rehypothesizing repeated until a better hypothesis is found.

A systematic entomologist, then, studies all aspects of insect life by any feasible means in order to add to and correct or refine our knowledge concerning insects, and thereby advances the possibilities of dealing with them in the fields of prediction and control.

Let us now consider a few concrete examples, selected more or less fortuitously, to illustrate how the systematist works and what he does or may accomplish. It should not be forgotten, in considering these examples, that by far the greatest number of insects species have close relatives that are not easy to distinguish from them, although sometimes their habits may be quite different. Even entomologists who are not systematists often lose sight of this fact.

1) *The imported fire ants in the United States.*—For over 30 years it had been supposed that only 1 species of *Solenopsis*, perhaps with two varieties, had entered the United States. Buren (1970) showed that two distinct species, *S. richteri* Forel, 1909, and *S. invicta* Buren, 1970 are present, with little or no hybridizing. He was able to do this by careful analysis of larger amounts of material and comparing it with more South American material than others had before his study. He also was able to consider differences in the chemical constituency of the venoms of the two species. He was thus able to set up a new hypothesis concerning the systematics of the organisms, one that agrees better with additional observed data.

2) *North American species of Rhagoletis (Diptera: Tephritidae).*—Prob-

lems of the taxonomic status of morphologically very similar fruitflies feeding upon different hosts were largely solved in a revision of the North American species by Bush (1966), whose objective was "to incorporate as much . . . biological information as possible into a reevaluation of these so-called host races. Additional observations made in three years of field and laboratory work on such aspects as the problem of chromosome cytology, courtship behavior, distribution, and host relations have also been included." Chromosome morphology aided considerably in defining the genus. He also stated that "certain aspects in the adaption to new hosts, such as the genetics and chemistry of host selection, conditioning, and mating behavior, have yet to be studied. The hosts of several species are still unknown and the distribution of most species, including those of economic importance, is yet to be definitely established."

3) *The genus Muscidifurax (Hymenoptera: Pteromalidae).*—*Muscidifurax raptor* Girault and Saunders, 1910, a parasite of the house fly, *Musca domestica* L., was considered to be the sole species of its genus and to occur in the southwestern United States, tropical America, Europe, and Africa, until Kogan and Legner (1970) made reciprocal crossing experiments which showed that some of the populations were reproductively isolated and noted other biological differences. Their study revealed five species with several morphological differences, even in the eggs. Scanning electron microscopy proved helpful in working with these small insects, the largest of which is 2.8 mm long. Van den Assem and Povel (1973), in studying three of these species, found differences in courtship behavior sufficient to act as a barrier to crossmating, at least in sympatric species,

4) *Species of Procecidochares (Diptera: Tephritidae) forming galls on weeds of the genus Ageratina.*—In 1947, Stone described *Procecidochares utilis*, which was collected in Mexico, the original source of the weed *Ageratina adenophora*, and introduced into Hawaii for biological control of the weed. When a second species of the weed, *A. riparia*, also became troublesome in Hawaii, it was found that *Procecidochares utilis* would not use it as a host. A search was then made, again in Mexico, for gall-forming flies on *Ageratina riparia*. Another species of *Procecidochares* was found and brought to Hawaii, where it was found to refuse *Ageratina adenophora* as as host. Adults of the flies on *A. riparia* were referred to me for determination. At first I could find only a small, doubtful difference in the pattern of the wing between the two flies, but knowledge of the host specificity induced me to look further. Finally good morphological differences were found in postabdominal details of both sexes and in eggs removed from ovaries. I described the species as new (Steyskal, 1974).

These examples could be extended *ad nauseam*. Nothing has been said here about phylogeny and higher classification. The practicing systematist is usually not a pure systematist in the sense of Wilson because he

does not have time for anything but classification and phylogeny, but because he must still deal with the species-distinction problems, what has been called "alpha" taxonomy. He usually hopes that someday he can do the big job, when the routine or teaching load permits. But even for the basic or elementary problems he must still be able to accumulate much material, often having to collect it himself; he must visit many museums; he should be able to rear his specimens; he should have the use of an electron scanning microscope; he should have computer time available; and he should have somebody to do some of the routine jobs, such as mounting specimens, making slides, keeping literature up-to-date, etc., etc., then perhaps he could do more and better primary systematics or even do large revisions, phylogenies, etc.

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Footnote

¹ Address of retiring 1976 President, delivered at the Society meeting held on 3 February 1977.

Announcement

The Second International Working Conference on Stored-Product Entomology will be held in Ibadan, Nigeria, 10-16 September 1978 at the Conference Centre on the campus of the University of Ibadan.

The purpose of the Conference is to provide a forum for intellectual and practical discussions on current research and future research needs in the context of the World Food Economy.

For information, inquiries should be addressed to:

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